NASA Conference Publication 3081

Space Transportation Avionics Technology Symposium

Volume 1—Executive Summary

Proceedings of a symposium held in
Williamsburg, Virginia
November 7–9, 1989

NASA
National Aeronautics and
Space Administration
Office of Management
Scientific and Technical
Information Division
1990

I

PREFACE

The Space Transportation Avionics Technology Symposium in November was the culmination of an idea, discussions and a process begun in the Spring of 1989. The Symposium was a success because of the contributions by the invited speakers, the panel leaders, and all of the panel participants. Their contributions are appreciated.

There were also a number of people, who participated in the planning and direct support of the Symposium that should be recognized for their significant efforts and contributions :

The NASA Inter-Center Steering Committee members;

Gary Beasley (LaRC)	Lott "Whit" Brantley (MSFC)
Don C. Brown (JSC)	John DiBattista (NASA Hq./RC)
Paul Herr (NASA Hq./MDT)	

The Panel Rapporteurs from NASA Headquarters;

Robert Bristow	William Dijinis
Sandra Griffin	Kimberly Ulrich

The Avionics Division secretary, Deborah Landry (JSC)

The SRS Technologies/Washington Operations Division staff members;

Paul Ammann	Kaye Anderson	Gregory Guthrie
Wm. Hope	Rodney Johnson	Jack Suddreth
Sue Taylor		

The Symposium was held to provide a forum for communication within the diverse avionics community. Because of the support and the enthusiastic participation by the Symposium participants, it was a success and will provide dividends within NASA, and within the avionics disciplines for years to come.

Kenneth Cox

Dr. Kenneth Cox
General Chairman,
Space Transportation Avionics
Technology Symposium

EXECUTIVE SUMMARY

OF THE

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

WYNDHAM HOTEL
WILLIAMSBURG, VIRGINIA

NOVEMBER 7-9, 1989

INTRODUCTION

The Space Transportation Avionics Technology Symposium (STATS) was held at the Wyndham Hotel in Williamsburg, Virginia, 7-9 November 1989. The symposium was established in response to a need identified by NASA Headquarters, Codes M and R, and the Chief of the Avionics Division at JSC, to provide a forum for avionics technology users and providers. The participants exchanged technical information to examine the sufficiency of NASA's avionics technology program to support the technology needs of existing and proposed future programs.

A working group of representatives from HQ, JSC, LaRC, and MSFC was formed to plan and organize the Symposium and to invite participation of key avionics representatives from NASA technology and operations centers, commercial sector prime contractors, associated avionics subcontractors, relevant DOD Laboratories, and DARPA.

The focus of the Symposium was to examine existing and planned avionics technology processes and products and to recommend necessary changes for strengthening agency priorities and program emphases. Innovative changes in avionics technology development and design processes, identified during the Symposium, are needed to support the increasingly complex, multi-vehicle, integrated, autonomous space-based systems. Key technology advances make such a major initiative viable at this time: *digital processing capabilities, integrated on-board test/checkout methods, easily reconfigurable laboratories, and software design and production techniques.* The incorporation of advanced avionics systems and capabilities will require changes within the NASA organization and operational environment.

In particular, activities associated with Systems Engineering and Integration (SE&I) were identified as requiring significant culture changes within NASA to propagate (or extend) the cost and operational benefits available from the application of new avionics technologies.

APPROACH

The purpose and objectives for the Symposium are listed in **Figure 1**. The agenda, **Appendix I-1**, was developed by the Working Group to promote (or encourage) a comprehensive statement of NASA programs technology needs and to give definition to the status of promising major technology thrusts in the areas of Flight Elements, Operational Efficiency, Payload Accommodations, and Systems Engineering and Integration. Functional panels were developed to address each area. As shown in **Appendix I-2**, each panel was co-chaired by technical representatives from NASA Centers, Headquarters, and the ALS-JPO. A broad definition of "avionics" allowed the symposium members to address the global aspects of modern avionics systems.

NASA program "needs" for seven major space transportation topics were addressed in pre-symposium white papers. These white papers were distributed to the technology provider panel chairpersons to help focus their planning for the review of specific avionics technology topics during STATS. Summary presentations topic were then presented during the first plenary session of the Symposium. The seven topics and the presenters are listed in **Figure 2**.

A format of quad-charts was selected to organize and describe compactly the key elements of each technology topic, and at the same time to facilitate information exchange and dialogue. See example set in **Appendix I-3a & 3b**. White papers that embody the substance of key discussion items during STATS for each technology topic will be published (post-symposium) in separate NASA Conference Publication document (NASA CP-3081, Vol. 2).

The Symposium was well attended by a total of 192 participants, representing a broad and diverse cross-section of the avionics technical community. The

Purpose of the Symposium

Space Transportation Avionics Technology Symposium is a forum for avionics technology information interchange between NASA technology developers and users, and for senior manager review of ongoing efforts and related research and technical facilities.

Symposium Objectives

- Review technology user needs vs. technology developer's on-going programs . Identify "holes" and technologies that have potential for improved capabilities.
- Identify NASA institutional avionics facility environments, such as simulators and computational systems along with ground and flight test beds, which should be developed.
- Facilitate better utilization of existing technology
- Identify key technical issues in the future space transportation systems.
- Define methodologies and techniques for incorporation of advanced avionics in both existing and evolving system/vehicle concepts.
- Develop technology demonstrations to support operational program management assessment of transportation avionics technology readiness.

Figure 1 Purpose and Objectives of the Symposium

distribution of attendees by organization is described in **Figure 3**.

The General Chairman, Dr. Kenneth Cox, in the opening address, established the thrust and direction for the Symposuim. He provided a defined scope of interest, a retrospective view of the current situation in avionics technology development, his vision of the future for consideration by the attendees, and recognition of factors that influence avionics planning. Three charts used by the General Chairman in his "overview and charge" to the attendees are included as **Figures 4a-4c**.

Each Symposium panel developed a report addressing perceived technology "holes" between NASA program needs and the planned technology programs. The findings and results from the STATS have now been briefed to senior NASA managers and should be helpful in providing direction for strategic and tactical planning for future NASA avionics technology initiatives.

• STS	D. WINTERHALTER	CODE M
• NMTS TO LEO AND RETURN	H. ERWIN	JSC
• CARGO SYSTEMS & ELV'S	G. AUSTIN	MSFC
• LEO FACILITY	A. EDWARDS	CODE S
• PEOPLE RETURN	D. MYERS	JSC
• ON-ORBIT TRANSPORTATION	F. HUFFAKER	MSFC
• EXPLORATION	I. BECKEY	CODE Z

Figure 2 Strategic Avionics Planning

DISCUSSION

In the plenary session on the first day of the Symposium, overall NASA and Office of Space Flight (OSF) future space transportation system plans were described in detail. Future space transportation systems were used as a base reference for avionics technology and subsystems requirements, mission performance, and operational conditions, and on the second day each panel convened separately to review, debate, and evaluate the current status of the avionics technologies available within their panels' specific charter.

Essentially all work of the Symposium was accomplished in the four concurrent panel sessions. Hence, the Executive Summary concentrates on the reports and conclusions of the four panels. The methodology and deliberations of each independent panel is provided in **Appendix II-V** for readers with an interest in the specifics of a panel's activities. The eight space transportation systems "needs" papers presented, as well as the "white paper" for each topic considered are provided in the companion NASA-Conference Proceedings.

Although each panel conducted reviews and evaluations independently and used different approaches, many similarities and a remarkable consistency shows in their conclusions:

1. All panels concluded that the avionics technology base available to NASA has the potential to satisfy perceived

NASA 120

HQ	20
JSC	39
MSFC	24
LaRC	17
LeRC	5
ARC	4
GSFC	1
SSC	2
JPL	3
KSC	5

GOV'T 7

DARPA	1
Space Division	6

UNIVERSITIES 2

New Mexico State Univ.	1
University Of Houston	1

TOTAL 192

INDUSTRY 63

Aerospace Corporation	1
Boeing	3
Draper Lab	3
Ford Aerospace	1
General Dynamics	2
Harris Corporation	1
Honeywell	5
IBM	4
Lincom Incorporated	1
Litton	1
Lockheed	3
Martin Marietta	10
McDonnell Douglas	4
Mitre	1
RDA	1
Rockwell	11
SRS	7
TRW	1
United Technologies	2
Vitro	1

Figure 3 STATS Attendees by Organization

avionics requirements for future space transportation systems. However, programmatic and organizational impediments exist which handicap incorporation of these advanced avionics technologies.

- The NASA organization is sometimes fragmented. Technology transfer is restricted.
- A bridging program for accomplishing advanced development programs with transfer and acceptance by the user/operator (NASA Program Offices) is needed.

2. All panels identified deficiencies or "holes" that must be addressed in future avionics technology planning. Deficiencies are defined in general terms and can be addressed over time through the conduct of orderly, goal-oriented projects and programs. A strategic plan must be developed to define priorities and provide the time phasing required to establish future space transportation systems capabilities.

    - One panel named five specific, high priority technology demonstration programs shown in **Figure 5.**

3. All panels expressed concern that methodologies for ground and flight operations, developed by and within NASA over the last several decades, have become rigid and inflexible to the extent that changes cannot be incorporated easily into the space transportation system to effect efficiency improvements and increased productivity, or cost control. Observations included:

    - The NASA "culture" must change and become amenable to abandoning the "business as usual" syndrome.
    - Incentives, within the NASA management structure and for contractors, are required to induce desired changes.
    - Leadership at the highest levels is required to motivate the cultural change process.

- FOR THIS SYMPOSIUM, THE SCOPE OF AVIONICS WAS CHOSEN TO INCLUDE
    - AVIONICS AS AN ELEMENT OF FLIGHT SYSTEMS
    - AVIONICS SUPPORT TO PAYLOAD SYSTEMS
    - AVIONICS SUPPORT TO OPERATIONS GROUND INFRASTRUCTURE
    - AVIONICS SUPPORT TO SE&I ACTIVITIES
- THE SYMPOSUIM HAS BEEN ORGANIZED TO ADDRESS STRATEGIC TECHNOLOGY WITH CUSTOMER-DRIVEN EMPHASIS

Figure 4a STATS Overview

- TECHNOLOGY IN THE PAST HAS LARGELY BEEN BASED UPON SUPPORT FOR GROUND-BASED FLIGHT SYSTEMS THAT DID NOT COUPLE STONGLY WITH OTHER FLIGHT ELEMENT PROGRAMS
- TWO FOCUS AREAS ARE APPROPRIATE AS A VISION FOR THE FUTURE
  - NEED A STRONG EMPHASIS ON DECREASING OPERATIONAL COST OF EXISTING SYSTEMS
    - TECHNOLOGY FOCUS TO ENABLE CONTINUOUS IMPROVEMENT OF OPERATIONAL SYSTEMS INCLUDING BOTH FLIGHT ELEMENTS AND GROUND INFRASTRUCTURE
    - MAY REQUIRE A DIFFERENT WAY OF DOING BUSINESS
  - FUTURE TECHNOLOGY TO ADDRESS SIGNIFICANT REQUIREMENT CHANGES
    - SPACE-BASED OPERATIONS
    - LONG DURATION MISSION
    - ASSEMBLY IN SPACE
    - INTERACTION OF FLIGHT SYSTEMS

Figure 4b STATS Technology Charge

4. All panels expressed concern that "standardization" of design, specifications and operational practices need to be developed and incorporated and/or installed into NASA operations. Suggestions were made for outreach to commercial industry, other government agencies, and technical societies.

   - Commercially available products, equipment and services could be beneficial to NASA for reducing costs and simplifying procedures.

5. The Payload Accommodations Panel recognized that this area is strongly dominated by interface issues, and is still evolving. Payload accommodation does not enjoy sufficient maturity or definition. Due to the unique nature of payloads definition for NASA missions, there may never be a high degree of standardization for payload interfaces. These deficiencies and the importance of payload accommodation avionics to NASA led this Panel to plan to reconvene early in 1990. Efforts will be continued to establish the extent/limits of their interests, to clearly define the technologies involved in the payload accommodation disciplines, and to establish the priorities and schedules necessary to develop a program for the avionics strategic plan.

- FAULT TOLERANT AVIONICS ARCHITECTURE DEMONSTRATION ON ALS BY MAY 1990
- LABORATORY DEMONSTRATION OF A FIBER OPTIC BUS AT 4 GBIT TRANSMISSION RATE
- POWER SYSTEM AUTONOMY DEMONSTRATION BY 1990
- EMA DEMONSTRATION IN THE 25-75 HP RANGE FOR THE ALS BY 1992
- EXPERIMENTAL COCKPIT FACILITY FOR NEXT GENERATION SHUTTLE ORBITER

Figure 5 Major Avionics Demonstrations

6. The SE&I Panel recommended (and several panels discussed) that NASA incorporate Total Quality Management (TQM) concepts into all future space transportation programs.

Each Chairperson presented the conclusions of their panel's deliberations to a plenary session on the last afternoon of the Symposium. Each presentation was further defined through a question and answer session with the audience at large.

- STRATEGIC TECHNOLOGY DEVELOPMENT
- POTENTIAL CULTURAL CHANGES
- PROGRAM MANAGER/CUSTOMER ACCEPTANCE
- CONSTRAINTS ASSOCIATED WITH EXISTING FLIGHT ELEMENT/ GROUND INFRASTRUCTURE RETROFITS OR NEW BUILDS
- TQM/SE&I CONTINUOUS PRODUCT IMPROVEMENT PROCESS
- RECONFIGURABLE/SHARED GROUND FACILITIES

Figure 4c Factors in Developing a Strategic Plan

Consistency existed among the opinions and conclusions of all panels. The major conclusions and opinions have been consolidated and combined for this Executive Summary. The four recurring themes from all panels are shown in **Figure 6**.

- Increased emphasis on automating vehicle systems (with recommendations in five specific areas);
- Effect integration across flight projects (with four areas specifically named);
- Develop powerful hardware to avoid complex software; and
- Require multifunction systems to avoid replacement from obsolescence of single function systems.

The panels also generated a set of general observations, shown in **Figure 7**. These

- INCREASED EMPHASIS ON AUTOMATING FLIGHT VEHICLE
  - HEALTH STATUS MONITORING
  - ONBOARD TEST AND CHECKOUT
  - SYSTEM TESTABILITY DESIGN
  - ONBOARD FLIGHT DESIGN PROCESS
  - INFLIGHT CREW TRAINING
- INTEGRATION ACROSS FLIGHT PROJECTS
  - FUNCTIONAL COMMONALITY
  - STANDARDIZATION
  - MODULARITY
  - INTERFACE ENGINEERING
- BUILD APPROPRIATE COMPLEXITY INTO HARDWARE EARLY AND AVOID COMPLEX SOFTWARE
- UTILIZE TECHNOLOGY TO DEVELOP MULTIFUNCTION SYSTEMS/ SENSORS AS OPPOSED TO SINGLE FUNCTION BOX REPLACEMENT

Figure 6 STATS Recurring Themes

observations recognize that NASA has the necessary capabilities to address advanced avionics technologies but for a variety of reasons has not concentrated the funding directly to the problem areas identified. Panel members recognized the need to decrease operational costs and addressed major reasons for the cited deficiencies.

A final conclusion suggested a pro-active management approach to establish specific programmatic actions required to support both near and longer term NASA needs. **Figure 8**, "Strategic Avionics Technology Processes for the 90's", defines a strategic, time-phased planning process. The process builds on evolving program needs, and then initiates an avionics technology program in FY91 and FY92 derived from these needs. The process builds on the synergism of the combined activities of Codes M and R to satisfy the NASA objectives.

SUMMARY

The STATS has provided clear and specific statements of NASA's long term avionics technology development needs. Because of the breadth of the Symposium objectives, the participants recognized their conclusions and recommendations would have to address a wide range of issues. There was consensus among the participants; the major issues were recognized, clearly defined, and stated. The General Chairman and the Code M and R Co-Chairmen will present briefings to NASA management and provide the necessary follow-up actions.

The remaining conclusions address programmatic issues which can be accomplished within the program authority already available to Codes M and R. These conclusions are summarized in **Figure 9**. As shown in this figure, TQM has been initiated with a workshop in January 1990 and the planning process for development of a Strategic Avionics Plan will be incorporated as a part of the FY90 program. Activities for FY91 and FY92, in **Figure 9**, include establishment

- SIGNIFICANT POCKETS OF TECHNICAL EXCELLENCE EXIST THROUGH OUT NASA
- PRESENT SPACE AVIONICS TECHNOLOGY MONEY NOT WELL FOCUSED
  - TOO MANY DISCONNECTS BETWEEN PROGRAM OFFICES AND INSTITUTIONAL TECHNICAL DISCIPLINES
  - NEED FOR IMPROVED PROCESS BETWEEN TECHNOLOGY CENTERS AND DEVELOPMENT CENTERS
  - NEED FEEDBACK ON EFFECTIVENESS OF TECHNOLOGY, DOLLARS SPENT THIS YEAR IN ORDER TO ALLOCATE NEXT YEARS BUDGET
  - STRONGER EMPHASIS NEEDED ON STRATEGIC TECHNOLOGY THAT HAS A CUSTOMER-DRIVEN FOCUS
  - NEED FEEDBACK ON HOW WELL TECHNOLOGY IS RECEIVED AND INCORPORATED INTO OPERATIONAL SYSTEMS
- NASA NEEDS A STRONG FOCUS ON DECREASING OPERATIONAL COSTS OF EXISTING SYSTEMS
  - TECHNOLOGY CAN HELP, BUT OTHER FACTORS ARE INVOLVED
  - CONTINUOUS PRODUCT IMPROVEMENT PROCESS NEEDED
  - IN-DEPTH ANALYSIS OF AIRCRAFT (COMMERCIAL AND MILITARY) TEST AND CHECKOUT METHODS WOULD BE USEFUL
  - A DIFFERENT WAY OF DOING BUSINESS SHOULD BE CONSIDERED
    - THE KEY LIES WITH DEVELOPMENT OF EFFECTIVE COST INCENTIVE TOOLS AND PROCEDURES FOR ALL LEVELS OF MANAGEMENT
    - A PEOPLE EMPOWERMENT PROGRAM TO IMPROVE COPING WITH CHANGE WAS DISCUSSED
    - A FORMALIZED TRAINING PROGRAM TO ELIMINATE DISCONNECTS AND DISINCENTIVES SHOULD BE CONSIDERED
      - EMPHASIS ON SE&I AND PROGRAM MANAGEMENT
      - IDENTIFY AND ADDRESS CURRENT NASA CULTURE ISSUES
      - COMMIT TO AN AVIONICS TQM INITIATIVE

Figure 7 General Observations

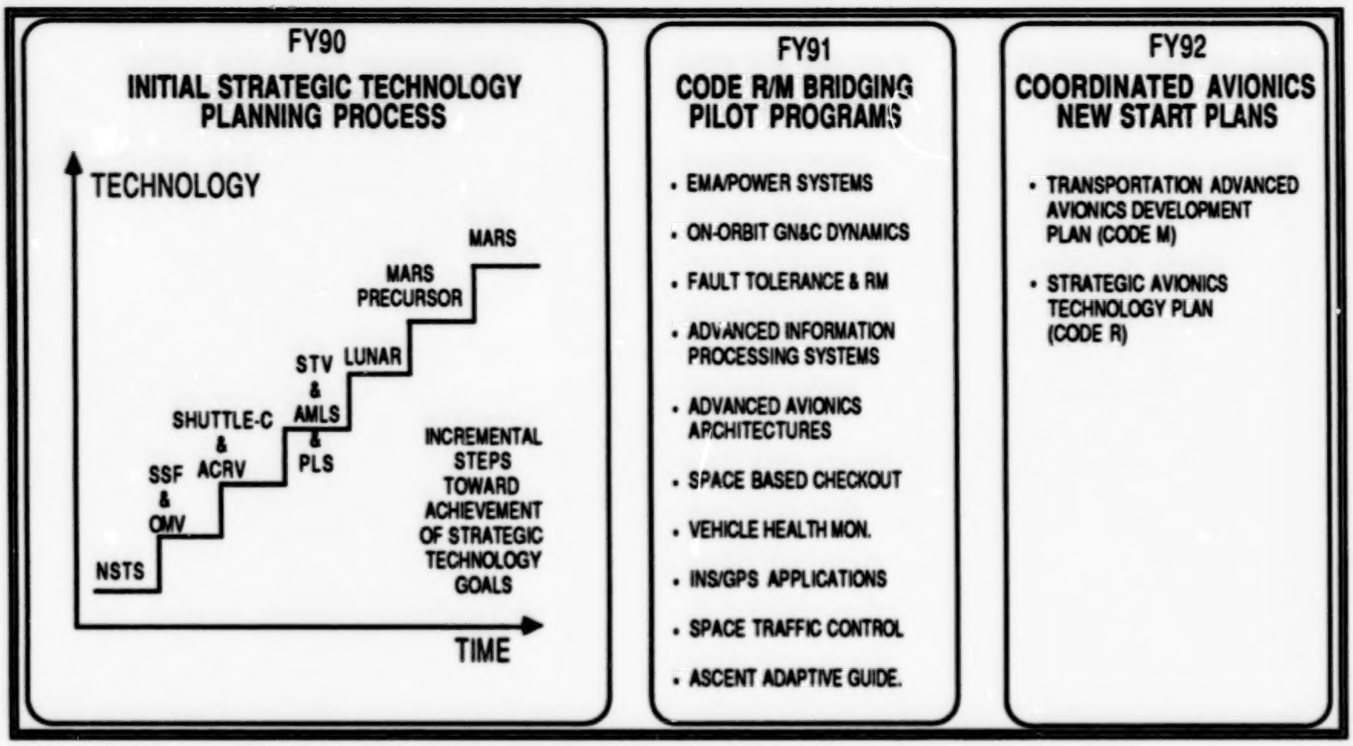


Figure 8 Strategic Avionics Technology Processes for the 90's

of "bridging technology" programs and Code M and R advocacy for coordinated Avionics Program "New Starts".

- TOTAL QUALITY MANAGEMENT AVIONICS WORKSHOP PLANNED AT JSC - JANUARY 18, 1990
- FY90: INITIAL STRATEGIC PLANNING PROCESS FOR AVIONICS AND ASSOCIATED SE&I
  - DEVELOP A STRATEGIC TECHNOLOGY PLAN FOR NSTS/SSSP AVIONCS - JSC/MSF/KSC
  - DEVELOP A STRATEGIC DEVELOPMENT PLAN FOR RECONFIGURABLE AVIONICS FACILITIES, NASA/CONTRACTORS
- FY91: PLAN CODE R/M BRIDGING PILOT PROGRAMS
  - EMA/POWER SYSTEMS - LeRC/JSC/KSC/MSFC
  - ORBIT GN&C/RMS DYNAMICS - LaRC/JSC
  - FAULT TOLERANCE & RM - JSC/ARC/LaRC/KSC
  - ADVANCED INFORMATION PROCESSING SYSTEMS - LaRC/MSFC/JSC/KSC
- FY92: PLAN COORDINATED AVIONICS NEW START
  - CODE R - STRATEGIC AVIONICS TECHNOLOGY
  - CODE M - ASSURED TRANSPORATION AVIONICS DEVELOPMENT

Figure 9 Summary

STATS RECOMMENDATIONS

The recommendations from the Space Transportation Avionics Technology Symposium are on three levels.

I. Apprise NASA Senior Management of the institutional and organizational changes required within NASA in order to develop and accommodate the next generation of space-based avionics technologies.

II. Develop a strategic long-range plan for the evolutionary development of necessary avionics technologies and immediately embark on a near-term program of highest-priority avionics technology development.

III. Build upon and exploit the organization from STATS to sustain a continuing multi-program SE&I review process by the formation of teams to evaluate, implement, and incorporate advanced avionics products into all future NASA space transportation systems. This recommendation is detailed in **Figure 10**.

The intent of STATS was to evaluate, understand, and postulate how advanced avionics technologies could be used to support future space transportation systems development and operation. The participants in the Symposium were successful in conducting the assessment as planned, and rendered a set of recommendations. It is the view of the participants, that these recommendations, if implemented, will go a long way toward assuring that NASA will be able to develop the capablities and robust avionics system designs necessary for future space-based transportation systems.

ESTABLISH A NASA HEADQUARTERS PANEL CHARTERED TO WORK MULTI-PROGRAM SE&I STRATEGIES • CONDUCT ANNUAL GLOBAL SE&I REVIEWS • ESTABLISH PRIORITY OF NEEDS TO MAXIMIZE USE OF TECHNOLOGY AND ADVANCED DEVELOPMENT • PROMOTE IMPROVED PROCESSES AND TRAINING AS WELL AS DEVELOPMENT OF EFFECTIVE COST INCENTIVES • CHARTER NASA TECHNICAL TEAMS TO STATUS TECHNOLOGY AND ADVANCED DEVELOPMENT PROCESS AT HEADQUARTERS PANEL MEETINGS

Figure 10 Recommendation

FIGURES & TABLES

AGENDA

Monday Evening

7:00-9:00pm	Registration		

Tuesday

7:30am	Registration/Continental Breakfast; Westminster Ballroom Foyer		
8:00-9:00am	Opening Remarks		
		-Call to Order	General Chairman
		-Welcome	R. Hook
		-Keynote Speaker	J. R. Thompson
9:00-9:30am	Symposium Overview		
		-Code MD	D. Branscome
		-Code RC	J. DiBattista
		-General Chairman's Comments	K. Cox
9:30-Noon	Summaries of User Technology Needs (45 min. each)		
		-STS	D. Winterhalter/ Code ME
		-NMTS to LEO & Return	H. Erwin/JSC
		-Cargo Systems & ELV's To LEO/Return	G. Austin/MSFC
		-Commercial ELV avionics	Martin Marietta McDonnell-Douglas General Dynamics
12:00-1:00pm	Lunch; Westminster Ballroom Foyer		
1:00-3:30pm	Summaries of User Technology Needs (30 min. each)		
		-LEO Facility	A. Edwards/Code S
		-People Return	H. D. Myers/JSC
		-On-Orbit Transportation	F. Huffaker/MSFC
		-Exploration	I. Bekey/Code Z
		-Reliability and Quality	D. Barney/Code Q
3:30-5:30pm	Symposium Subpanel Overviews (30 min. each)		
		-Flight Elements	C. Keckler/LaRC P. Sollock/JSC
		-Operational Efficiency	T. Davis/KSC D. Bland/JSC
		-Payload Accomodation	S. Cristofano/Code M A. Nguyen/ALS-JPO
		-SE&I	E. Chevers/JSC A. Haley/MSFC

Appendix I-1 STATS Agenda

AGENDA (Continued)

Wednesday		
7:15am	Continental Breakfast; Williamsburg Foyer and Westminster Ballroom Foyer	
7:45-8:30am	Joint Session Flight Elements & SE&I Panels: Risk Management of Large Electronic Systems at DARPA	Col D. Dougherty
8:30-8:45am	Subpanels Convene - Discuss and define process	Subpanel meetings
8:45-12:30pm	Review of specific technologies	Subpanel meetings
12:30-1:30pm	Lunch; Westminster Ballroom Foyer (Box Lunch)	
1:30-2:30pm	Continued review of specific technologies	Subpanel meetings
2:30-3:00pm	Break	
3:00-4:00pm	Additional Technical Topics	Subpanel meetings
4:00-5:00pm	Session Products - Review of "Holes" - Facility Requirements - Cultural Change Identification	Subpanel meetings
7:00-7:30pm	Reception/Cash Bar	
7:30-9:00pm	Colonial dinner with "light" entertainment	
9:00-10:00pm	Splinter meetings as required	
Thursday		
8:00am	Continental Breakfast; Williamsburg Foyer and Westminster Ballroom Foyer	
8:30-12:30pm	Assessment of technology maturity vs. needs - Preparation of panel summary	Subpanel meetings
12.30-1:30pm	Lunch; Colony Room	
1:30-3:30pm	Subpanel presentation of findings (30 min. each) - Each Technology Subpanel Chairperson	Plenary Session
3:30-4:30pm	Open Forum Discussions - Questions from the floor	General Chairman/All
4:30-5:00pm	Conclusions and Recommendations	Code MD/RC
5:00-5:30pm	Symposium Wrapup	General Chairman

Appendix I-1 STATS Agenda Continued

Appendix I-2 STATS Subpanel Themes

STATS SUBPANEL THEMES

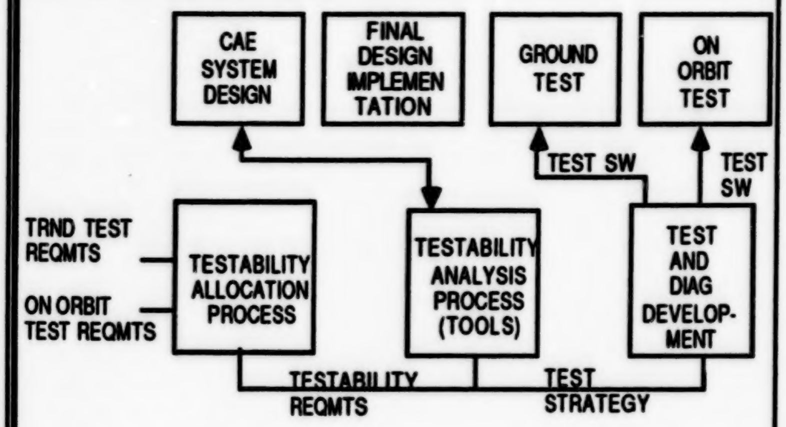
FLIGHT ELEMENTS*	OPERATIONAL EFFICIENCY*	PAYLOAD ACCOMMODATION*	SE&I*
• C. KECKLER-LaRC • P. SOLLOCK-JSC	• T. DAVIS-KSC • D. BLAND-JSC	• S. CRISTOFANO-NASA HQ • CAPT. A. NYUGEN-ALS /JPO	• E. CHEVERS-JSC • A. HALEY-MSFC
ADV. AVIONIC SYSTEMS ARCHITECTURES C. MEISSNER-LaRC	AUTO. FLIGHT DESIGN E. HENDERSON-JSC	NSTS PAYLOAD OPERATIONS J. MORAIN-HQ	AVIONICS ADV. DEV. STRATEGY D. DYER-RESTON
ADV. PROCESSORS J. DEYST-CSDL	ADV. TRAINING SYSTEM R. SAVELY-JSC	AVIONICS P/L SUPPORT ARCHITECTURE S. CREASY-JSC	RISK ANALYSIS & MGMT. H. E. SMITH-LE & SC
INTEGRATED GPS/GN&C A. ZEITLIN-ROCKWELL	TELEROBOTICS/TELEPRESENCE K. HALTERMAN-GSFC	SATELLITE SERVICING R. LEE-TRW	TOTAL QUALITY MGMT. K. SHIPE-MMC
ADV. DISPLAYS & CONTROLS J. HATFIELD-LaRC	AUTONOMOUS S/C CONTROL R. MERRIAM-JSC	ADV. CARGO INTEG.&INTER. VERIF. E. ZARRAONANDIA-KSC	LOW COST AVIONICS W. BRANTLEY-MSFC
ADV. COMM. & TELEMETRY K. LAND-JSC	OPERATIONS MGMT. SYSTEM A. BRANDLI-JSC	P/L DEPLOY. SYS.&ADV. MANIP. E. BAINS-JSC	COST ESTIMATION & BENEFITS J. HAMAKER-MSFC
ADV. SENSORS & INSTRUMENTATION R. CALLOWAY-LaRC	ADV. TEST C/O SYSTEM C. McCLESKEY-KSC	ADV. TELEMETRY SYS. H. VANG-JSC	COMP. AIDED S/W ENG. C. WALKER-LaRC
FAULT DETECTION & FAULT MGMT. H. LUM-ARC	ADV. MISSION CONTROL P. FRIEDLAND-ARC	ON-BOARD ABORT PLANNING A. BORDANO-JSC	H/W RECERT & S/W REL. C. MCKAY-UHCL
ADV. ELEC. POWER DIST. & CONTROL H. BRANDHORST-LeRC	ADV. SOFTWARE INTEGRATION J. GARMAN-JSC		SYSTEM TESTABILITY T. BARRY-JSC
EMA/POWER SYSTEMS G. SUNDBERG-LeRC	ATMOSPHERIC ADAPTIVE GUIDANCE D. PRICE-LaRC		ADV. AVIONICS LAB B. GATES-MMC
IN-FLIGHT CREW TRAINING S. MURRAY-JSC	HEALTH STATUS & MONITORING J. BAKER-P&W		RAPID PROTOTYPING SYSTEM P. SHOEN-ROCKWELL
William Dijinis*	Sandra Griffin *	Robert Bristow *	Kim Ulrich *

* Panel Rapporteur

Appendix I-3a STATS Example Quad Chart

STATS SE&I SYSTEM TESTABILITY

ADVANCED CONCEPTS:



MAJOR OBJECTIVES:

- OPTIMIZE TESTABILITY DESIGN PROCESS
- OPTIMIZE SYSTEM SUPPORTABILITY/AVAILABILITY
- PROVIDE ANALYTICAL TOOLS TO DEVELOP TEST STRATEGIES
- OPTIMIZATION OF FD/FI DESIGN
- MINIMIZE WEIGHT AND POWER OF BITE
- TESTABILITY PROCESS/TOOLS NOW MATURE
  - WIDELY USED BY DOD
  - NEED TO GET PROCESS/TOOLS INTO NASA MAINSTREAM

KEY CONTACTS:

B. ROSENBERG - HARRIS CORP
B. KELLEY - HARRIS CORP
W. KEINER - NAVY SUFACE WEAPON CENTER
J.T. EDGE - NASA JSC
R. CACERAS - MDC
H. MORROW - IBM
M. BATTAGLIA - NASA RESTON
D.. LANDWEIR - IBM
J. KLION - ROME AIR DEV. CENTER
A. STANLEY - ROCKWELL AUTONETICS
J. BUCCHE - GRUMMAN
E. FREDDOLINO - ROCKWELL, DOWNEY

MAJOR MILESTONES 1990-1995

- SPACE STATION TESTABILITY PROCESS/TOOLS IN PLACE PRIOR TO PDR
- TESTABILITY PROCESS BEING USED ON LHX/ATF 1991
- APPLY TOOLS TO SHUTTLE UPGRADES 1991
- PROOF OF CONCEPT ON NASA SYSTEM 1990
- IMPROVE TESTABILITY PROCESS/TOOLS WITH TECHNOLOGY DEVELOPED BY AI/EXPERT SYSTEMS TECHNICAL DISCIPLINES

Appendix i-3b STATS Example Quad Chart

FIGURE 4c. STATS SE&I SYSTEM TESTABILITY

ISSUES:

- TIMELY ACCEPTANCE BY SYSTEM DEVELOPERS
- LACK OF NASA APPLICATION/PROOF OF CONCEPT
- HOW MUCH TESTABILITY IS ENOUGH
- QUANTITATIVE RELATIONSHP OF TESTABILITY AND AVAILABILITY
- NON-UNIFORMITY OF CAE TO TESTABILITY TOOLS INTERFACES
- TOOL USER FRIENDLINESS

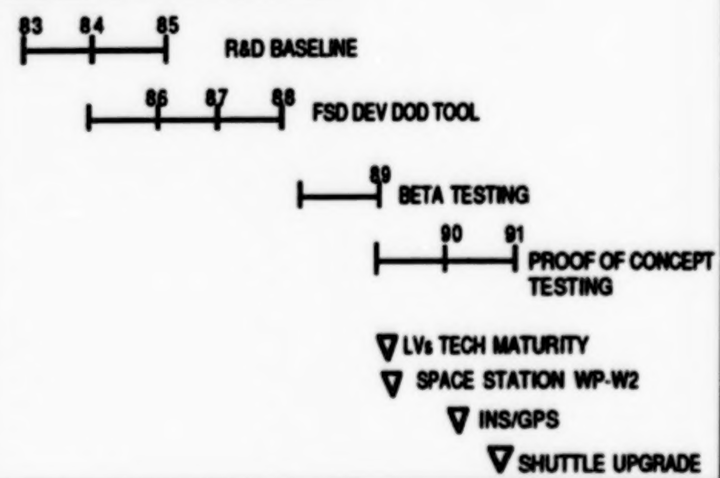
CANDIDATE PROGRAMS

- SPACE STATION - UNDERWAY
- CERV - CRITICAL FACTOR FOR VEHICLE CHECK-OUT/ AVAILABILITY
- SHUTTLE-C - REDUCE LAUNCH CHECK-OUT COST
- ALS - REDUCE LAUNCH CHECK-OUT COST
- SDI
- LUNAR MARS EXPLORATION - VISIBILITY INTO SYSTEM AVAILABILITY

MAJOR ACCOMPLISHMENTS:

- BETA TEST (10 SITES) OF DOD TESTABILITY TOOL COMPLETED (1989)
- INDUSTRY BRIEFED ON DOD TESTABILITY OBJECTIVES (1988)
- MIL SPEC 2165 TESTABILITY SPEC INVOKED ON ALL NEW DOD FSD PROGRAMS (1985)

SIGNIFICANT MILESTONES:



PANEL REPORT

Deliberations of the Flight Elements Panel

The Flight Elements Panel was co-chaired by Claude Keckler (LaRC) and Paul Sollock (JSC) and the Rapporteur for this panel was William Djinis (Code MDS/NASA Headquarters). The panel participants reviewed avionics technologies that have potential for providing improved capabilities in this area. The ten technology topics reviewed are listed below:

- Advanced Avionics Architecture
- Advanced Processors
- Integrated Global Positioning System / Guidance Navigation and Control (GPS/GN&C)
- Advanced Displays and Controls
- Advanced Communication and Telemetry
- Advanced Sensors and Instrumentation
- Fault Detection and Fault Management
- Advanced Electrical Power Distribution and Control
- Electro-Magnetic Actuators (EMA) / Power Systems
- In-Flight Crew Training

The panel critically reviewed the assigned topics, carefully assessed their relationship to future mission requirements, evaluated the status of each technology, assessed the potential for development, and determined whether it could provide the necessary capabilities in future space transportation systems applications. The Flight Elements Panel developed and provided three independent, stand-alone sets of observations, conclusions, and recommendations for consideration by NASA management. Three topics were addressed in the panel summary presentation:

1. Technology Holes *where technologies and/or the programs considered (or proposed) were deemed not sufficiently complete to fully satisfy future avionics system requirements.*

The panel identified 14 technology "holes". While each hole is important in and of itself, the panel actually concentrated its comments in six different areas of apparent deficiency.

- Capabilities: Six topics are currently technology limitated.
- Validation: Three topics require validation activities (including methodology and integration).
- Technical Decisions: Two topics require high level technical/ system decisions.
- Obsolescence: One topic addressed avionics technology evolution and down-time.
- Requirements Definition: One topic cites the absence of clear, timely, up-front definitions.
- Funding: One topic cites the absence of a funding schedule to provide future avionics capabilities when needed.

2. Cultural Changes *where NASA business methods or procedures now in use will not permit the technology to be utilized / exploited in future applications.*

The panel identified 11 topics that could provide major productivity improvements, cost reductions, systems simplification, and/or rapid turn around. The NASA culture limits or precludes benefits from accruing to NASA operations and will require change to permit the following:

- All weather launch capability and utilization
- Launch with onboard defects/failures
- Integration of flight systems and operations
- Planning across multiple programs
- Near-term user and technology insertion
- Program selling minimizes use of new technology
- Trade information not valid technical data
- Validation of changes only not total software package
- Utilization of commercial and other sector technology (eliminate NIH)
- Paperless management
- Reduction of operations "standing armies".

3. Major Demonstrations *where the panel recommends a program be conducted or performed to assure the prudent program manager that a technology is, in fact, capable of providing the performance, reliability, or cost control required.*

The Flight Elements Panel recommended five major avionics subsystem demonstrations. In three cases, they suggested programs and/or schedules that would accommodate the envisioned demonstrations.

- Fault tolerant avionics architecture demonstration on ALS by May 1990.
- Laboratory demonstration of a fiberoptic bus at 4 Gbit transmission rate.
- Power system autonomy demonstration by 1990.
- EMA demonstration in the 25-75 HP range for the ALS by 1992.
- Experimental cockpit facility for next generation Shuttle Orbiter.

PANEL REPORT

Deliberations of the Operational Efficiency Panel

The Operational Efficiency Panel was co-chaired by Dan Bland (JSC) and Tom Davis (KSC), and the Rapporteur was Sandra Griffin (Code MDO/NASA Headquarters). The panel reviewed ten technology topics, carefully evaluating and then reporting on each of four areas: key findings, technology needs, cultural changes and facilities.

In setting ground rules for the review, the Operational Efficiency Panel established the following conditions.

- Operational efficiency must cover all technology disciplines and programs.
- Cross panel technology needs should be integrated.
- The entire broad mix of program technology needs, technical discipline needs, and technology availability must be considered

The specified breadth allowed the panel to consider operational efficiency at a level that would provide NASA with a perspective of avionics technologies impact on current ground and flight operations, and it allowed the panel to consider how advanced avionics could contribute to improved operational efficiency as future system requirements are superimposed on existing capabilities.

Nine (reduced from the original ten) technology topics were considered by the panel.

- Ascent Flight Design (merger of Automated Flight Design and Atmospheric Adaptive Guidance)
- Autonomous Spacecraft Control
- Operations Management Systems
- Advanced Mission Control
- Telerobotics/Telepresence
- Advanced Software Integration
- Advanced Test/Checkout Systems
- Health Status and Monitoring
- Advanced Training Systems

The panel provided a complete and detailed review of the above topics in four areas: key findings, technology needs, cultural changes, and facilities. The full report of the Panel is included in the Conference Proceedings. The major finding of the panel is given in one statement:

Operational Efficiency is not a major technical problem.
It is a NASA Cultural (Political / Funding) Problem!

The panel members feel they know what needs to be done and how to go about achieving and installing operational efficiency into NASA ground and flight operations. The panel was concerned that unless cultural change can be initiated and implemented, none of the potential cost benefits available from advanced avionics will accrue to NASA. Incentives, in some form, are required for both NASA program and project managers and industrial contractors to force operational efficiency improvements into their organizations. NASA will need to establish the environment wherein these incentives are available and required in the conduct of programs, since operational efficiency is a summing process, resulting from many small incremental improvements.

PANEL REPORT

Deliberations of the Payload Accommodation Panel

To address the wide diversity of requirements within NASA and DOD, the Payload Accommodation Panel was co-chaired by Captain Ahn Nguyen (ALS-Joint NASA/DOD Project Office) and Salvatore Cristofano (Code MK/NASA Headquarters) with Robert Bristow (Code MDT/NASA Headquarters) serving as the Rapporteur. Seven papers were invited; however, only six were presented at the Symposium. Historically, because of the wide variety of spacecraft designs and the unique mission requirements, spacecraft have been forced into an interface accommodation with the launch vehicle, launch facility services, and existing space operations infrastructure. In most cases, the sponsoring spacecraft program office provides the vehicle interstage structure, power, most on-pad utilities including environmental control, the guidance interface and update, and data acquisition systems. The Shuttle payload interfaces are even more highly constrained and complex. Significant differences in spacecraft design and functional requirements exist, depending on whether they are designed by military, scientific, or exploration specialists; therefore very little standardization exists, and few coordinating forces are available within the technical (payload accommodation) discipline.

The Panel's approach to the report, possibly because of the diversity in payload interfaces, varied somewhat from the other panels' reports. Initial efforts were directed toward cataloging payload accommodation avionics needs, listing current technologies against needs, and identifying apparent technology deficiencies or "holes".

The panel identified a variety of technical "holes" but none were unique. They are similar to those identified by other panels and will not be discussed here; they are included in the Conference Proceedings.

The findings and recommendations of the Payload Accommodations Panels were tentative; they provided activities and specific issues to be resolved in providing the necessary details for a Strategic Plan that would address payload accommodation. The panel presented two major issues.

- **Increase operations efficiency for payload services through:**
  - Use of commercial/industry/DOD standards
  - Use of automation and expert systems
  - Maximum separation of host vehicle and payload accommodations
  - Standardized set of robust services
  - Modular design to accommodate growth and upgrades

- **Meet the need for increased safety through:**
  - Advanced onboard avionics software to enhance abort capability for payload return
  - Autonomous rendezvous and docking to allow local control of time- critical operations of unmanned vehicles.

The Panel presented the following summary.

- **Only a cursory look across payload accommodations subject was possible.**

- **Topics recommended for proposed next meeting**
  - Space-Based Transfer Vehicles
  - User Needs
  - Focus on Specifics

- **Systems engineering effort required**
  - Coordinate Disciplines and Programs (Vehicle/Payload)
  - Focus Technology Plan Across All Programs
  - Develop Commonality Across All Programs

PANEL REPORT

Deliberations of the Systems Engineering & Integration (SE&I) Panel

The SE&I Panel was Co-Chaired by Ed Cheevers (JSC) and Aubrey Haley (MSFC) with Kimberly Ulrich (Code ME/NASA Headquarters) serving as the Rapporteur. The panel had a large membership of which addressed ten diverse avionics technical topics.

The members of the SE & I Panel represented multiple, varied disciplines that emphasize and concentrate on "systems engineering" and "systems integration". The Panel deliberations were protracted, making a consensus of collective opinion difficult to achieve. However, the panel report addressed the issues at a high plane and captured issues present to one degree or another in the other panels. The SE&I summary was highly structured and very specific; their charts are replicated below:

Summary Outline

- **TOPICS**
  - Definitions
  - Requirements
  - Cost
- **RISK / REDUNDANCY MANAGEMENT**
  - Standards
  - Testbed
  - Operations

Definitions

- **SE&I must be recognized as the total infrastructure that is established to control methods, policies, and procedures for present and future NASA programs.**
- **SE&I includes the development of generic tools needed to support and enforce the methods, policies, and procedures defined for specific programs.**

Requirements

- **Must develop better methods for defining total set of needs; also requirements for multiple set of programs:**
  - Create fully functioning true chief engineer's office at NASA Headquarters.
  - Do SE&I across all programs.
  - Establish priority of needs to maximize use of technology.
- **NASA should require demonstration of functional equivalent of final product during Phase B.**
  - Move Preliminary Requirements Review (PRR) from Phase C/D to Phase B.

Cost

- **NASA has history of underestimating the cost of projects.**
- **A life cycle cost-control philosophy must be applied during the development phase.**
  - Cannot drop features in DDT&E that cost later in operations.
- **Be aware that overestimating becomes a self-fulfilling prophecy; we tend to spend whatever we predict.**
- **NASA must come up with incentives for contractors to agree with reuse concepts. Currently, no reason exists for contractors to propose reuse of hardware or software.**
  - No incentive procedures/policy within NASA.
  - No guidelines for configuration control enforcement.
  - No guidelines for quality management implementation.
- **NASA needs to formally adopt Total Quality Management (TQM).**
  - Establish short term (1 year) products/benefits.
  - Demonstrate results.
  - Define mid/long term (3-7 year) goals.

Risk / Redundancy

- **Develop backbone of analysis capability for risk management in the form of easy to use tools that can be tailored by each project to its specific needs.**
  - i.e., spreadsheet format and each project fills in the data.
- **Redundancy / fault-tolerance management must be part of generic SE&I toolset and not unique to each project.**
  - Does not mean that some program specific tailoring cannot be done, but it is a general guideline for all programs.

Standards

- **NASA and SE&I must take an active, leading role in standards committees (AIAA, IEEE, etc.).**
  - Take strong role in directing industry to establish standards that benefit NASA.
- **Establish a NASA-Aerospace Industry Working Group to define interface standard between NASA laboratories and industry which will allow sharing of data, models, etc.**
  - Force some level of commonality between NASA Centers.

Testbed

- **Consider concept of "NASA National Testbed" but do not restrict concept to single center or location.**
  - Create complementary set of interconnected labs based on functional expertise fo each center.
- **Recognize labs are for benefit of individuals responsible for subsystems in addition to establishing confidence for program management.**
- **Must create policy and tools for testability across projects.**

Operations

- No check and balance system for NASA in operational phase. Since NASA is the buyer, the developer, and the user, we have no mechanism or incentive to reduce costs.

- There must be a culture change at NASA, emanating down from the Administrator, which forces technology insertion into projects that result in cost/efficiency benefits -- even if the action moves the funds to another program.

NASA National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CP-3081		

4. Title and Subtitle	5. Report Date
Space Transportation Avionics Technology Symposium Volume 1 - Executive Summary	August 1990
	6. Performing Organization Code MD
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address NASA Office of Space Flight	11. Contract or Grant No.
	13. Type of Report and Period Covered Conference Publication
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The Space Transportation Avionics Technology Symposium was held in Williamsburg, Va., November 7-9, 1989. The focus of the symposium was to examine existing and planned avionics technology processes and products and to recommend necessary changes for strengthening priorities and program emphases. Innovative changes in avionics technology development and design processes, identified during the symposium, are needed to support the increasingly complex, multi-vehicle, integrated, autonomous space-based systems. Key technology advances make such a major initiative viable at this time: digital processing capabilities, integrated on-board test/checkout methods, easily reconfigurable laboratories, and software design and production techniques.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
space transportation avionics digital processing software space-based systems	Unclassified - Unlimited Subject Category 06

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	26	A03

NASA FORM 1626 OCT 86 Available from the National Technical Information Service, Springfield, VA 22161

NASA-Langley, 1990

25